Wastewater Treatment Plant Operator Certification Training Instructor Guide

Module 15: The Activated Sludge Process Part 1

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:

The Pennsylvania State Association of Township Supervisors (PSATS)
Gannett Fleming, Inc.
Dering Consulting Group
Penn State Harrisburg Environmental Training Center

A Note to the Instructor

Dear Instructor:

The primary purpose of *Module 15: The Activated Sludge Process–Part I*, which is the first in a series of four modules, is to provide an overview of the activated sludge process, aeration systems, and new plant start-up procedures. This module has been designed to be completed in approximately 3 hours, but the actual course length will depend upon content and/or delivery modifications and results of course dry runs performed by the Pa. DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the Pa. DEP course approval process. To help you prepare a personal lesson plan, timeframes have been included in the instructor guide at the Unit level and at the Roman numeral level of the topically outline. You may need to adjust these timeframes as necessary to match course content and delivery modifications made by the sponsor. Please make sure that all teaching points are covered and that the course is delivered as approved by Pa. DEP.

Web site URLs and other references are subject to change, and it is the training sponsor's responsibility to keep such references up to date.

Delivery methods to be used for this course include:

- Lecture
- Small group and full group discussion
- Case Study
- Quizzes

To present this module, you will need the following materials:

- One workbook per participant
- Extra pencils
- Laptop (loaded with PowerPoint) and an LCD projector or Overheads of presentation and an overhead projector
- Screen
- Flip Chart
- Markers

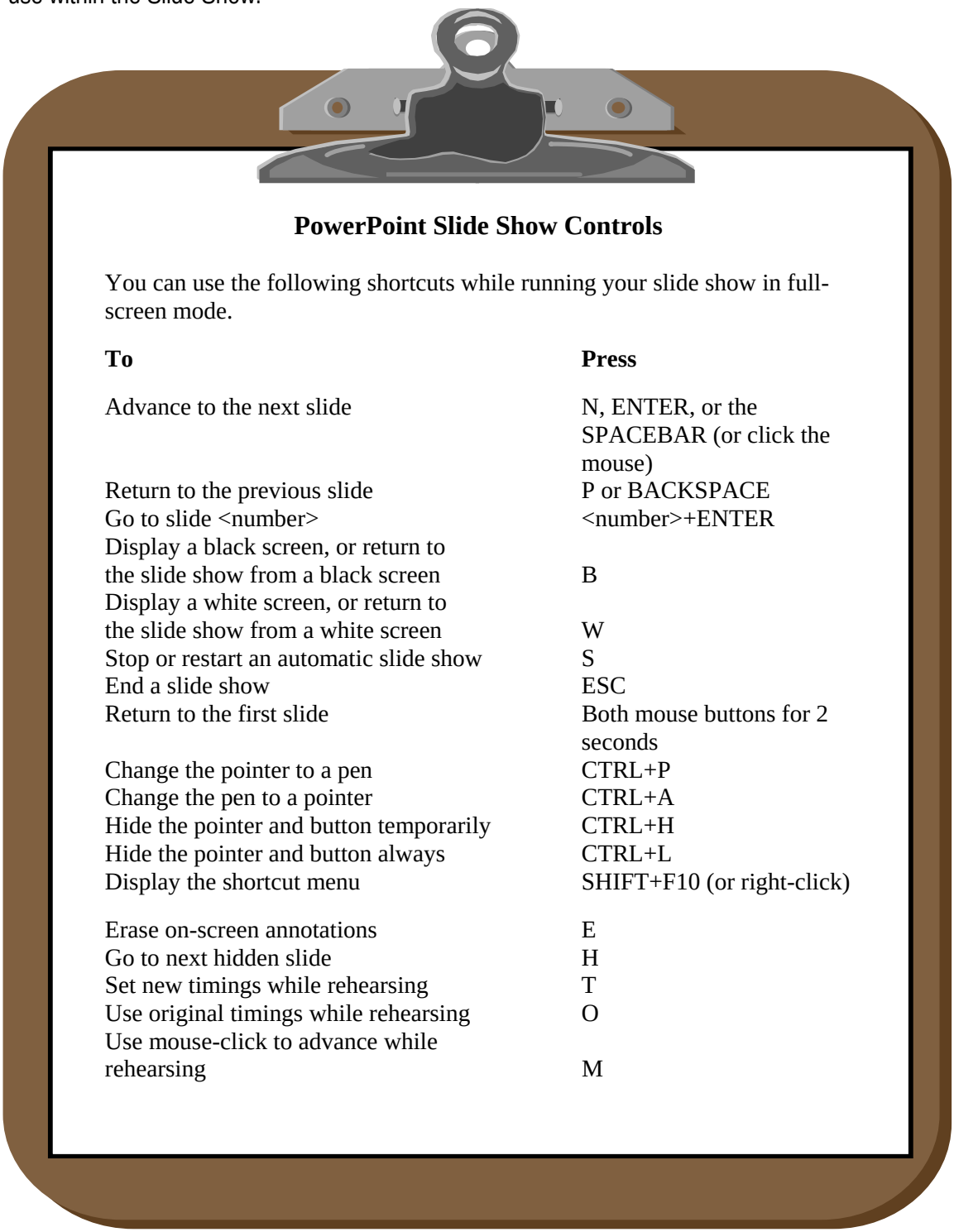
Icons to become familiar with include:

Participant Workbook		Instructor Guide	
	Exercise/Activity	Same icons for Participant Workbook apply to the Instructor Guide.	
	Case Study	Ans:	Answer to exercise, case study, discussion, question, etc.
	Discussion Question		PowerPoint Slide
	Calculation(s)		Overhead
	Quiz		Flip Chart
	Key Definition(s)		Suggested "Script"
	Key Point(s)		

Instructor text that is meant to be general instructions for the instructor are designated by being written in script font and enclosed in brackets. For example:

[*Ask participants if they have any questions on how to read the table. Answer any questions participants may have about how to read the table.]*

If your module includes the use of a PowerPoint presentation, below are some helpful controls that you may use within the Slide Show.



PowerPoint Slide Show Controls

You can use the following shortcuts while running your slide show in full-screen mode.

To	**Press**
Advance to the next slide	N, ENTER, or the SPACEBAR (or click the mouse)
Return to the previous slide	P or BACKSPACE
Go to slide <number>	<number>+ENTER
Display a black screen, or return to the slide show from a black screen	B
Display a white screen, or return to the slide show from a white screen	W
Stop or restart an automatic slide show	S
End a slide show	ESC
Return to the first slide	Both mouse buttons for 2 seconds
Change the pointer to a pen	CTRL+P
Change the pen to a pointer	CTRL+A
Hide the pointer and button temporarily	CTRL+H
Hide the pointer and button always	CTRL+L
Display the shortcut menu	SHIFT+F10 (or right-click)
Erase on-screen annotations	E
Go to next hidden slide	H
Set new timings while rehearsing	T
Use original timings while rehearsing	O
Use mouse-click to advance while rehearsing	M

INTRODUCTION OF MODULE: 5 minutes

[Display Slide 1, Module 15: The Activated Sludge Process – Part I

You may want to have the slide up while participants are arriving so they know they are in the right place.

Welcome participants to "Module 15: The Activated Sludge Process–Part I"

Introduce yourself.

Provide a brief overview of the module. The primary purpose of Module 15: The Activated Sludge Process–Part I, which is the first in a series of four modules, is to provide an overview of the activated sludge process, aeration systems, and new plant start-up procedures.]

This module contains three units. On pages I and ii, you will see the topical outline for Unit 1 – General Description of the Activated Sludge Process, Unit 2 – Aeration Systems, and Unit 3 – New Plant Start-Up Procedures.

[Continue to briefly review outline.]

UNIT 1 – GENERAL DESCRIPTION OF THE ACTIVATED SLUDGE PROCESS: 65 minutes

[Display Slide 2, Unit 1: General Description of the Activated Sludge Process

Review the Learning Objectives.]

At the end of this unit, you should be able to:

- Describe the activated sludge process and its control variables.
- List three types of activated sludge treatment plants.

DEFINITION OF THE ACTIVATED SLUDGE PROCESS: 10 minutes

We will begin this unit by covering Definitions of activated sludge and the activated sludge process.

Activated Sludge

[Review the definition for activated sludge that appears at the top of page 1-2 of the participant workbook.]

Activated Sludge Process

[Display Slide 3, Activated Sludge Process (Figure 1.1 in participant workbook)

Review the defintion for the activiated sludge process that appears in the workbook. Use Figure 1.1 to illustrate the process. Point out:

1.The Aeration Tank, including:

- *where the wastewater enters the tank (Wastewater Feed) and*
- *where the activated sludge enters the tank.*

2. *Oxygenation and aeration occur in the aeration tank (arrows in aeration tank).*
3. *Activated sludge is allowed to settle out in the Clarifier.*
4. *Activated sludge is disposed of (Waste Activated Sludge) or reused (Return Activated Sludge).]*

Let's continue in our workbooks for a more detailed review of the characteristics of the activated sludge process.

[Review the remaining information on the Activated Sludge Process.]

[Complete the review of the characteristics of the activated sludge process.

As a class, discuss the following question and explore possible answers.]

What purpose does the activated sludge process serve within wastewater treatment?

Ans: To oxidize and remove soluble or finely divided suspended materials that were not removed by previous treatment (preliminary and primary).

We are now going to move on to a more detailed description of the activated sludge process.

THE ACTIVATED SLUDGE PROCESS DESCRIPTION: 30 minutes

Organisms

[Review the two main classifications of organisms found in the activated sludge process. Stress that aerobic organisms are the most effective and efficient within the activated sludge treatment process.]

A discussion of all the different types of organisms found in activated sludge is beyond the scope of this module, but is presented in another of the activated sludge training modules.

[Ask participants if they have any questions about Organisms. Answer questions as needed.]

Secondary Clarification

[Review the purpose of clarification in the workbook material.

Display Slide 4, Rectangular Sedimentation Clarifiers (Figure 1.2 in Participant workbook)

Present the slide showing the rectangular clarifiers. Briefly point out the common elements and how they work. Note the influent and effluent locations, the adjustable weirs that control the liquid level in the clarifier, the scum trough, and the sludge hopper.]

1. Influent enters at the sludge hopper end and effluent discharges from the scum collecting end. As the wastewater flows through the clarifier, solids settle to the bottom and scum rises to the top.

[Next point out the principal difference between the two:]

2. The chain and flight collector uses a gear mechanism to rotate a chain around the clarifier. The chain has flights (scapers) mounted on it that move the sludge from the bottom of the clarifier to the sludge hopper.

3. The traveling bridge collector moves back and forth along the clarifier. While moving in one direction it positions a scaper to collect solids from the bottom of the clarifier and deposit them in the sludge hopper. While moving in the opposite direction, the bottom scraper is idle but a skimmer blade is activated to propel scum to the scum trough.

[Display Slide 5, Typical Circular Clarifier (Figure 1.3 Participant Workbook)

Briefly discuss how they work:]

- In a) the influent enters at the bottom center and discharges into the clarifier at the center top. A circular baffle forces the flow toward the bottom of the clarifier. Effluent flows over a weir to a collection trough. Scaper arms move sludge from the bottom of the clarifier to the center sludge trough.

- In b) the influent enters via the perimeter of the clarifier, is directed downward by a perimeter baffle, and then flows up to the effluent collection troughs. A counterbalanced suction arm collects sludge from the bottom of the clarifier using a vacuum.

- In c) influent again enters at the perimeter but in this case flows down and around back to the perimeter to the effluent trough. As in a), scraper arms move sludge from the bottom of the clarifier to the center sludge trough.

Controlling the waste activated sludge is a key component of a successful activated sludge plant. Let's take a look at how RAS and WAS impacts the activated sludge process.

[Review the material on RAS and WAS.]

Table 1.1 illustrates how management of WAS can impact the activated sludge process.

Review of the material in this table is beyond the scope of this module, but the table illustrates the complexity of the activated sludge process and provides some idea of the knowledge required to properly operate an activated sludge process.

Activated Sludge Process Control

The activated sludge process needs to be closely controlled in order to have it perform as intended. To determine what controls are required, it is necessary to understand what the characteristics of the incoming wastewater are and how the activated sludge process is performing. This is done by quality testing of influent water and testing the activated sludge process. Let's take a closer look at how we test the quality of influent water.

Incoming Wastewater

[Review the information that deals with sampling of influent wastewater.

Ask the class to respond to the following question:]

When the biochemical oxygen demand (BOD) of incoming wastewater increases, what happens to the air requirement in the aeration tank?

Ans: Air requirements increase—more food (BOD) encourages biological activity, which in turn requires more air (oxygen).

Activated Sludge Process Testing

A number of process variables will impact the performance of the activated sludge process. These include the mass of organisms in the aeration tank, the sludge age, the dissolved oxygen concentration, the proper distribution of flow to parallel treatment units, and management of RAS and WAS. Let's take a brief look at these parameters.

[Review the material on sludge concentration.

Review the material on sludge age. Incorporate the following information:]

Sludge age controls the length of time an organism remains in the process. Manipulating the sludge age changes the type of organisms that can survive in the activated sludge.

- Bullet 1—Sludge age affects mixed liquor settleability, which directly affects effluent BOD.
- Bullet 2—The activated sludge particles from a young sludge (less than three days) settle rapidly and do not produce as clean an effluent.
- Bullet 3—A younger sludge will not oxidize the waste as thoroughly. Consequently, less oxygen will be required for each pound of BOD removed from the wastewater.
- Bullet 4—An older sludge will affect sludge production since less sludge is being wasted and more is being recycled through the aeration tank.

Sludge age can be calculated several different ways depending on how much of the sludge in the activated sludge process is accounted for. Some calculations use only the sludge under aeration, some include the clarifier volume too, others use the sludge blanket volume only, which is based on the depth of the sludge in the clarifier, rather than the entire clarifier volume, and others use the mass of sludge wasted in the denominator rather than the mass of sludge added to the system. These are all proper methods to calculate sludge age; the key is to be consistent no matter which way you choose to do the calculation.

[After reviewing the sludge age equation, lead the participants through the calculation of the following example.

Record your mathematic operations on the flip chart as you walk participants through the process.]

Let's calculate the sludge age for an activated sludge process if the aeration volume is 0.5 million gallons (MG) and the mixed liquor suspended solids concentration is 2,100 mg/L. The influent flow is 4.0 MG per day and the primary effluent suspended solids concentration is 70 mg/L.

1. Determine the pounds of solids under aeration:

   2,100 mg/L x 0.5 MG x 8.34 = 8,757 pounds

2. Determine the pounds of solids in the primary effluent:

   70 mg/L x 4.0 MGD x 8.34 = 2,335 pounds per day

3. Divide the solids under aeration by the solids in the primary effluent to get sludge age:

   8,757 pounds/2,335 pounds per day = 3.75 days

Later in this unit we will discuss the importance of sludge age on the various types of activated sludge processes.

[Review information on dissolved oxygen, flow splitting, and solids handling.

Ask participants if they have any questions regarding the materials covered. Provide the answer or elicit answers from other participants. (Caution: do not entertain questions specific to one participant's situation. Instead, turn the question into a generic one in which all can benefit or refer the participant to where he or she can obtain the answer.)]

ACTIVATED SLUDGE PLANTS: 20 minutes

Activated Sludge Plants

There are three basic operational modes for activated sludge plants, based on the sludge age maintained in the process: high rate, conventional, and extended aeration. Let's first look at the high rate modification.

High Rate

A high rate activated sludge treatment plant is operated so that the amount of food available exceeds the capacity of the organisms to stabilize it.

[Review the material in the workbook. Cover the characteristics of the modification as well as its benefits and detriments.]

Conventional

A conventional activated sludge treatment plant is operated so that the amount of food available for the organisms is limited, requiring the organisms to compete for the available food.

[Review the material in the workbook. Cover the characteristics of the modification as well as its benefits and detriments.]

Extended Aeration

An extended aeration treatment plant is operated so that the amount of food introduced into the process is not sufficient to support net organism growth (i.e. organisms die at a rate equal to their growth rate). In this mode, the organisms must obtain some of their food by breaking down their own cellular material.

[Review the material in the workbook. Cover the characteristics of the modification.]

[Complete the review of the chief benefits and detriment of extended aeration.]

Variables That Impact Plant Operation

The task of the activated sludge treatment plant operator is to provide the proper environment for the efficient conversion of colloidal and dissolved solids into settleable biological floc.

[Review material in workbook on influent BOD and changing waste characteristics, then discuss the following example:

As an example, a high organic load can push the F/M ratio out of the acceptable operating range causing degradation in the effluent quality (because not enough organisms are available to process the available food).

Review bullet 1 for WAS, then note:]

For example, increasing the sludge wasting rate causes a decrease in the available organisms that grow more slowly (if they cannot grow as fast as they are being discharged by the wasting process). Similarly, decreasing the wasting rate gives the slower growing organisms an opportunity to become predominant and impacts the nature of the activated sludge process.

[Review bullet 2.]

[Review the material in the workbook on dissolved oxygen level.

Display Slide 6, Ideal Growth Curve for Batch-Type Activated Sludge Unit (Figure 1.4 in participant workbook)

☑ *Lead a class discussion of the figure by doing the following:*

1. *Explain the figure to the class as follows:]*
    a. The vertical axis represents the amount of mass (microorganisms or food) at any point in time
    b. The horizontal axis represents the time the batch process has operated and increases from left to right
    c. The solid line, decreasing in mass from left to right, represents available food in the system
    d. The dashed line, peaking in the center of the figure, represents the mass of microorganisms in the system at any point in time.

2. *[Ask the class to relate the figure to the lecture material just completed, i.e., the three types of activated sludge modes. Participants should observe the following:]*
    a. During the high rate range (equivalent to the high rate activated sludge process), microorganisms are growing quickly (increasing slope of dashed line), but note that in that range, there is still lots of food available (that portion of the solid line to the right of the high rate range)
    b. During the conventional range (equivalent to the conventional activated sludge process), microorganisms are growing very slowly if at all (slope of dashed line is almost horizontal = no growth). Note also that the conventional range occurs after a longer period of time, compared to the high rate range. Also note that little food is available at this point (height of the solid line to the right of the conventional range).
    c. During extended aeration, the microorganisms are in an endogenous phase. This means that microorganisms are dying faster than they are reproducing, causing a decline in the microorganism population. Note that during endogenous respiration phase, the microorganisms are utilizing their own cell mass for food because of the low concentration of food available in the system (low F/M ratio). The height of the solid line in the extended aeration range shows how little food is available.

[Instructor can explain that in a continuously operated activated sludge treatment plant (not the batch process depicted in the figure), the plant operator will control the activated sludge process so that it operates in a narrow time range shown on this figure, such as the range associated with the conventional process. Ideally, the operator will strive to operate at a single point on the figure, but that is not practical.]

[Review the Key Points for Unit 1 on this page.]

Unit Exercise: 5 minutes

1. Why is air added to the aeration tank in the activated sludge process?

Ans: Air is added to the aeration tank in the activated sludge process to provide oxygen to sustain the living organisms as they oxidize the wastes to obtain energy for growth. The application of air also provides mixing to ensure that the oxygen and food (BOD) are distributed to all the organisms.

2. What does the volatile content of the mixed liquor suspended solids represent?

Ans: The volatile content of the mixed liquor suspended solids represents the amount of microorganisms in the activated sludge process.

3. What influences the amount of air required in an aeration tank?

Ans: The amount of food (BOD) in the wastewater and type of treatment are the principal influences on the amount of air required in the aeration tank.

4. Aerobic organisms grow relatively quickly, efficiently oxidize waste, produce little or no odor, but require a proper amount of dissolved oxygen to function properly.

   a. True b. False

5. The conventional activated sludge process produces a high quality of effluent and the process has some ability to absorb _shock_ loads.

6. As the water temperature drops, water will be able to dissolve:

   a. more oxygen b. less oxygen

We have completed Unit 1. Are there any questions before we move on to Unit 2?

[Respond accordingly.]

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UNIT 2: AERATION 80 minutes

[Display Slide 7, Unit 2: Aeration]

The purpose of this unit, Aeration Systems is to provide a basic knowledge of the aeration process and the equipment used to aerate wastewater.

At the end of this unit, you should be able to:

- Explain the purpose and methods of aeration.
- Identify four types of mechanical aeration.
- Describe the three types of diffusers.
- Describe plant safety procedures around an aeration tank.

PURPOSE AND METHODS OF AERATION: 10 minutes

In order to appreciate the need for maintaining the aeration system in good working order and recognize when the aeration system is not operating properly, we need to understand the purpose of aeration. We will begin this unit by covering both the purpose and methods of aeration.

Purpose of Aeration

[Review purpose of aeration.]

This is where all the elements needed for microorganisms to do their work in the Activated Sludge Process are brought together. Aeration serves two purposes:

1) providing dissolved oxygen and

2) mixing the mixed liquor and wastewater in the aeration tank.

Once dissolved in the wastewater, the oxygen can be utilized by the microorganisms in the mixed liquor suspend solids to help break down the food supply (organic contaminants). The mixing process ensures that the microorganisms are intimately contacted with the oxygen and the food supply so the processes of decomposition begun by the microorganisms can continue effectively.

Aeration Methods

There are two basic methods of aerating wastewater. They are mechanical aeration and diffused aeration. While mechanical aeration utilizes devices that either splash or mix air into the wastewater, diffused aeration uses a pressurized air supply to both add and mix the air into the wastewater. How many of you work in plants where mechanical aeration is used? [Survey the class.] How about diffused aeration? [Survey the class.] [Comment on the numbers—which is more/less represented. Indicate that you will be calling on their experience as they go through this unit.]

We will begin our review with mechanical aeration.

AERATION SYSTEMS 30 minutes

Mechanical Aeration Systems

[Review the information on mechanical aeration.

Display Slide 8, Mechanical Aeration Device (Figure 2.1 in participant workbook)]

Let's take a closer look at this Mechanical aeration device. The aerator shown is a platform-mounted mechanical aerator—sometimes referred to as a surface mount. It is a partially submerged design, so that when operating it will create a vortex to draw air into the water and also will splash water into the air. The aerator is motor-driven through a gearbox (located between the motor and the impeller).

[Point out the electrical motor—across from first bullet; the platform mount—across from second bullet; and the submerged impeller—across from third bullet.]

For those of you who work in plants with mechanical aeration, is this similar to the one you use? Does anyone work with one that is a lot different? [If yes, ask, "How?" Encourage the participant to speak loud enough so that everyone can hear and to use the slide to point out where the differences are.]

*[Complete the review of **Equipment** and **Submerged Turbine Aerators**.]*

Submerged turbine aerators are another type of motor-driven mechanical aerator. It incorporates an outside source of air usually delivered from a blower or oxygen-generating system. This added air helps to make this hybrid more efficient and use less horsepower because of the extra turbulence added by the rising air bubbles.

Are there any questions about the mechanical aeration process or the equipment used?

[Respond to questions as needed or ask experienced participants to assist with answers and provide missing information if needed.]

Let's move on to the other aeration system—diffused aeration.

Diffused Aeration Systems

Diffused aeration systems are the most common. Can anyone tell me why this might be true? *[Select a participant who works at a plant that uses diffused aeration.]*

Ans: More versatile, mobility, cost effective—can make repairs which do not require shutting down the whole tank, can adjust airflow to be more efficient, etc.

[Review information on diffused aeration systems.

Display Slide 9, Fine Bubble Air Diffuser (Figure 2.2 in participant workbook)]

In this slide you can see the air bubble moving up the tank coming from the tube diffuser. The air that you see as bubbles has come from a blower through a piping systems and then into the tank through the diffuser. Let's continue on learning about diffused aeration systems.

[Review the information on the design of diffused aeration systems and the placement of diffusers.]

The path or order in which the air travels through the components is very important. We will be reviewing the major components in the order found. We will start with the filters. Although it may seem premature to be filtering air, it is not. The primary purpose of the filters is to keep the diffusers clean. This is done by removing dust and dirt BEFORE the air is compressed and transferred to the diffusers. This is important because the diffusers, especially fine-bubble diffusers, have very small openings for the air to pass through.

[Review the information on filters.]

Blowers

In aeration systems, there are two types of process air compressors known as **blowers**. They are positive displacement blowers and centrifugal blowers. Let's first look at positive displacement blowers.

[Display Slide 10, Mechanical Aeration Device (Figure 2.3 in participant workbook)]

This slide is an illustration of the cross section of one type of blower, a rotary positive displacement blower. The rotors can be seen in the center. If a filter is not functioning properly, the rotors could become clogged or something could get stuck in the gears which could affect the overall efficiency of the system.

[Review the material on the characterization of positive displacement blowers.]

The next section, Output Control Mechanisms, refers to those features of blower assemblies that can be adjusted to affect air output.

[Review the material on output control mechanisms.]

The other type of blower is a centrifugal blower.

[Display Slide 11, Centrifugal Blower (Figure 2.4 of participant workbook) as a transition to the next page.]

Although you really can't differentiate size in these pictures, you certainly can see that the centrifugal blowers are more complex than the positive displacement blowers. Let's move on to learn about the characteristics of centrifugal blowers.

[Continue to display Slide 11. Review the material on centrifugal blowers presented in the participant workbook.]

We have discussed centrifugal and positive displacement blowers and the differences between the two. In summary, positive displacement blowers operate at a constant volume and deliver a variable pressure that depends on the system needs. Centrifugal blowers deliver a volume that varies inversely with the pressure required by the system.

Are there any questions?

[Try not to spend more that 5 minutes responding to questions. Take only those questions that would benefit the learning of all participants. Individual cases should be dealt with privately.]

After the air has passed through the filters and blowers, it needs to travel to the diffusers through a system of piping.

[Discuss Figure 2.4 which shows photos of centrifugal blowers.}

Air Piping Systems

While we are reviewing this section, I want you to be thinking about the two types of air piping systems and which you think might be more efficient and effective. We will be talking about that a bit later. But I want you to make your own judgment.

[Display Slide 12, Air Distribution Piping (Figure 2.5 in participant workbook).

Review the material on air piping systems. Incorporate the following information:]

Air piping is an important component of the aeration system. Not only does it carry the pressurized air to the diffusers, but it can also serve as a distribution mechanism to ensure that air is distributed evenly to the various diffusers and to the aeration basins themselves.

[Use Slide 12 to point out pipes, valves, and metering devices.]

[As you review the information on the page:

Display Side 13, Swing Header (Figure 2.6 in participant workbook)]

In this slide, you can easily see the pivot elbow (6) which allows this particular header to bend and the hoist (10) that can lift the header (8) out of the tank.

[Display Side 14, Fixed Header (Figure 2.7 in participant workbook)]

In this slide, you can see the pipes and elbows are secure and the headers (4) are firmly in the tank.

[Complete the review of material on air piping systems covering valve and metering devices.]

As I had mentioned earlier, the air piping system is the system that transfers the air from the blowers to the diffusers. Now, that we have traveled from the blowers through the air piping system, it's time to move on to diffusers.

Diffusers

[Review items on ***diffusers*** *and fine bubble diffusers. State why you are putting air into the wastewater—to dissolve oxygen into the wastewater and to intermix the mixed liquor suspended solids and the incoming wastewater. Explain the difference the diffuser makes on the size of the bubbles.*

Note that for the same air volume (which relates to horsepower used and dollars spent) smaller bubbles will have a greater surface area for oxygen transfer than larger bubbles.

Review the material on ***Fine Bubble Diffusers****. You may want to refer participants back to Figure 2.2 and ask if anyone remembers what design this is an example of. (Ans: tube.)]*

[Display Side 15, Medium Bubble Diffusers (Figure 2.8 in participant workbook)]

This nylon sock is a sample of one type of medium bubble diffuser. For those of you in diffused aeration plants, how many use a nylon sock similar to this?

[Review information provided on medium bubble diffusers.

Review items on coarse bubble diffusers.]

As we have discussed, diffusers are available to cover a wide range of oxygen transfer efficiencies, and with a range of maintenance needs and costs.

Now let's find out something about the treatment plants you work in.

What type of aerators is used in your treatment plant? If you have a diffused aeration system, what type of diffusers is used? What performance issues or maintenance issues are you familiar with for your system? Which type of air piping system do you think would be the most efficient and effective?

Ans: [There are no set answers, but you could use prompts to solicit responses if none are forthcoming. Ask how many have mechanical aerators and ask about performance and maintenance issues. Also, ask how many have diffused aerators and prompt those people for additional information.]

We've talked about the purposes and methods of aeration, the processes, and the equipment used. The final section in this unit, deals with SAFETY. We can never be too conscientious about safety.

SAFETY PROCEDURES: 20 minutes

[Practicing good safety procedures can never be emphasized enough. While we do not want to encourage participants to take short cuts, asking them to share anecdotal stories that would emphasize the importance of ALWAYS practicing safety may help send the message home.

Review the material on safety procedures both general and specific to aeration tanks and clarifiers, surface aerators and air filters.]

[Continue the review on safety procedures for blowers, air distribution systems, and air headers and diffusers.]

[Present the following scenario to the class and solicit responses from the participants.]

[Write the answers provided on a flip chart.]

Safety Case Study (10 minutes out of the 20 allotted)

You are an operator at a wastewater facility where you will be changing the diffusers in an aeration tank. The aeration lines are equipped with swivel joints, so you can keep the tank in service during the change out. There was a rain shower an hour before the scheduled change out. Please identify safety concerns associated with this operation and how you would address the concerns to make the operation safer.

Ans:

Concern	Possible Solution
Slips, trips, and falls	▪ Make sure the walking surface is clean and dry (remove slime and brush away standing water). ▪ Keep handrails in place, if possible. ▪ Wear fall arrest device.
Drowning	▪ Wear flotation device. ▪ Shut off aeration to the header being serviced.
Overhead falling hazards	▪ Wear hard hats. ▪ Ensure lifting devices are securely attached. ▪ Ensure lifting devices are functioning properly.
Pressurized line	▪ Relieve the line pressure prior to any work. ▪ Wear protective eyewear.

[Note to instructor: Other answers are possible.]

[Be sure to caution the class that the Standard Operating Procedures for each facility take precedence over suggestions made during this training session.]

[Have the class review the Key Points for Unit 2 – Aeration.]

UNIT EXERCISE: 20 MINUTES

[Divide the class into small groups. Ask the small groups to respond to the questions.

Debrief small group responses to questions. Ensure that each of the suggested answers is represented. (Allow 10 minutes for debrief.)]

1. What are the purposes of aeration?

Ans: To dissolve oxygen into the wastewater and, to mix the mixed liquor suspended solids with the incoming wastewater. Both of these functions are necessary to ensure the survival of the microorganisms that actually remove the contaminants from the wastewater.

2. What is the difference between mechanical and diffused aeration?

Ans: Mechanical is done by contacting atmospheric oxygen with the wastewater, either by drawing air into the water or by splashing water into the air. Diffused aeration is done by oxygen or air being "blown" under pressure into the depths of the wastewater through a diffuser.

3. What are the precautions that must be taken before one attempts to maintain or repair a surface aerator?

Ans: Wear the proper clothing floatation – fall arrest... Turn off machinery. Turn off electricity (tag out/lock out) Wait for motion to STOP.

4. What are some of the hazards that could be found when working on air headers?

Ans: Because of the location of air headers, slips, trips, and falls are potential hazards. Also, if the work involves lifting, such as with a hoist, care must be taken to ensure that the hoist cable is properly connected; that personnel do not work beneath the hoist or the load; that the hoist is in good working order; and that the load if lifted properly. Finally, if the air line is to be opened, pressurized air, carrying dust or small particles, could be released at a high rate of speed unless the pressure is released first under controlled conditions.

We have completed Unit 2. Are there any questions on the material we have covered thus far?

[Respond to questions as necessary. Offer a five minute break or continue on with Unit 3.]

UNIT 3 – NEW PLANT START-UP PROCEDURES: 55 minutes

[Display Slide 16, Unit 3: New Plant Start-up Procedures

Review the objectives with class.]

At the end of this unit you will be able to:

- Explain the purpose of plant and equipment review prior to plant start-up.
- List equipment and structures that need to be checked.
- Explain the plant start-up procedure.

PURPOSE OF PLANT AND EQUIPMENT REVIEW: 10 minutes

Document Familiarization

[Review the various forms of documents the operator is expected to review: Operation and Maintenance Manual, manufacturer's manual for each piece of equipment, and record plans.

As you review the information, make sure that participants understand that this is for starting up a new plant. Indicate that once a plant is up and running, an operator will want to become familiar with maintenance checks and records as well as other documents.]

Equipment Familiarization

[Review the information in the workbook.

Ask for a volunteer to answer the following question.]

If your waste treatment plant were missing a particular manufacturer's manual, how would you go about obtaining one?

Ans. Usually the contract specifications require that several copies of manufacturers' manuals be provided. If they are lost, call or write to the manufacturer or contact the manufacturer's representative and request another copy of the manual. If the manufacturer's representative does not have the necessary equipment information, you will need to provide it. Be prepared to provide the equipment serial number, which should have all the necessary information. As additional verification, provide the equipment model number and size, and a purchase contract number if available.

EQUIPMENT AND STRUCTURES CHECK: 25 minutes

Over the next five pages we will take a look at what we would look for during our equipment and structures check by system or grouping. Let's start with flow control gates and valves.

Flow Control Gates and Valves

Check Valves for Seal and Function

[Review the information as presented in the workbook.]

Record Data: Valve Positions, Turns, Opening Direction

[Review the material and incorporate the following:]

As a plant starts up, there will be no "historical data" for the plant. The manufacturer's materials may give an expected performance standard. However, it is important for plant operators to set up a system of record keeping that will ensure effective monitoring of the valves.

Touch Up Protective Paint Coating and Lubricate Valves

[Review the material in the workbook.]

Piping and Channels

Inspect Piping and Channels.

[Review the information in the workbook and incorporate the following:]

Usually the installation contractor is required to check the integrity of piping systems and to perform a pressure check based on the contract specifications. When this is done, it is unlikely that debris of significance would remain in the piping. However, it is during initial plant startup that it is the most likely time for debris to be encountered. This could be packing materials or almost anything that was placed inside the unfinished piping during construction.

Repair Protective Coatings as Necessary

The old adage, an ounce of prevention is worth a pound of cure, truly holds up in regards to equipment maintenance in a wastewater treatment plant.

[Review the material in the workbook.]

Weirs

[Review the information in the workbook.

Ask participants the following question and select a volunteer to answer. If you do not get a satisfactory answer, ask one or two more participants, then offer the answer provided.]

Why should an effluent weir be level?

Ans. An effluent weir should be level to prevent short-circuiting of effluent, to maintain the intended overflow rate, and to minimize solids carry-over, which could occur if high velocity flow patterns are created by the uneven weir setting.

Froth Control System

[Review the equipment and structures check for froth control system as presented.]

Air System

[Review the equipment and structures check for the air system as presented.]

[Continue to review the equipment and structures check for the air system as presented in the workbook.]

Check Blowers

[Review startup checklist, emphasizing the need for a systematic approach.]

Check All Air Headers for Leaks

[Review the role of headers, and explain the importance of eliminating leaks as an energy-conservation step.]

Check Diffusers

[Discuss briefly both the steps in the process of checking diffusers and the reasons for being certain to do so.

Again, ask for responses from participants for the following question.]

As a review, how is air cleaned before it is compressed and sent to the aeration tank?

Ans. Air filters are used to clean the air.

Secondary Clarifier

[Display Slide 17, Secondary Clarifier (Figure 3.1 in Participant Handbook)

While reviewing the information on secondary clarifiers, use this slide to illustrate where and how the control gate operation and return and waste sludge pump checks identified in the workbook will take place.]

Once all equipment and system checks have been completed, the process start-up is begun. The remaining part of this unit addresses process start-up. But, before we move on, are there any questions on equipment check or any material presented so far?

[Respond to questions as needed (not more than 5–10 minutes) then move on.]

PROCESS START-UP: 15 minutes

Process Units

There is a methodical procedure implemented when it comes to starting up process units. First, we put them on line one at a time. Then, within that process there are various checks that are done. Let's start by taking a look at an aeration tank.

[Display Slide 18, Aeration Tank (Figure 3.2 in participant workbook)

Review material on aeration tank start-up, using slide to help illustrate the process.

Review material on secondary clarifier start-up.]

[Continue reviewing the process start-up for disinfection system and froth spray system.

Complete the process start-up review by asking the following question:]

Blowers should be started prior to admitting primary effluent to the aeration tank. Why?

Ans. Blowers should be started and air should be flowing to the diffusers before primary effluent is admitted to the aeration tank to prevent the diffusers from clogging. Without the air discharging through the diffusers, solids would settle on and stick to the diffusers, but with the air discharging that is less likely.

We've just talked about start-up of process units. Once started, there needs to be some monitoring and adjusting. We refer to this as process control. This is the last step in the start-up process.

Process Control

[Review material on process control regarding air system and dissolved oxygen (DO) levels.]

Rapidly Return Clarifier Solids

[Review the material in the workbook.]

Testing

It is through the testing that we know how effective and efficient the activated sludge process is running.

[Review the material in the workbook.]

UNIT EXERCISE: 10 MINUTES

[Have the class review the Key Points for Unit 3 – New Plant Start-up Procedures.]

[Ask all participants to respond to the following questions in their workbook.
Review the answers for the questions (Allow 5 minutes for debrief.)]

1. Why must the horizontal pipes containing the air diffusers all be at the same elevation (level)?

Ans: If the diffusers are not all at the same elevation, the higher diffusers will receive too much air and the lower diffusers will not receive enough (or any) air. This is because the higher diffusers would have less water pressure on them so there would be less resistance to flow. Uneven air distribution would make oxygen transfer less efficient and disrupt the normal mixing pattern in the aeration tank.

2. Why should an operator completely check the equipment and structures before startup?

Ans: The main reasons to check equipment and structures prior to startup are to: a) become familiar with the equipment, b) learn how it works, c) learn where all the controls are located, d) make sure it is installed properly, and e) have confidence that it should function properly when started up.

3. The Operations and Maintenance (O&M) manual, if available, should contain a wealth of information concerning how to run the plant.

4. Record plans will summarize the as-constructed information about the plant.

5. Out of level weirs can cause an imbalance of flows in the plant and potentially cause problems with the plant effluent.

   a. True b. False

This concludes the formal instruction for Module 15: The Activated Sludge Process – Part I.

[Ask for and respond to questions.

Thank attendees for their participation.]